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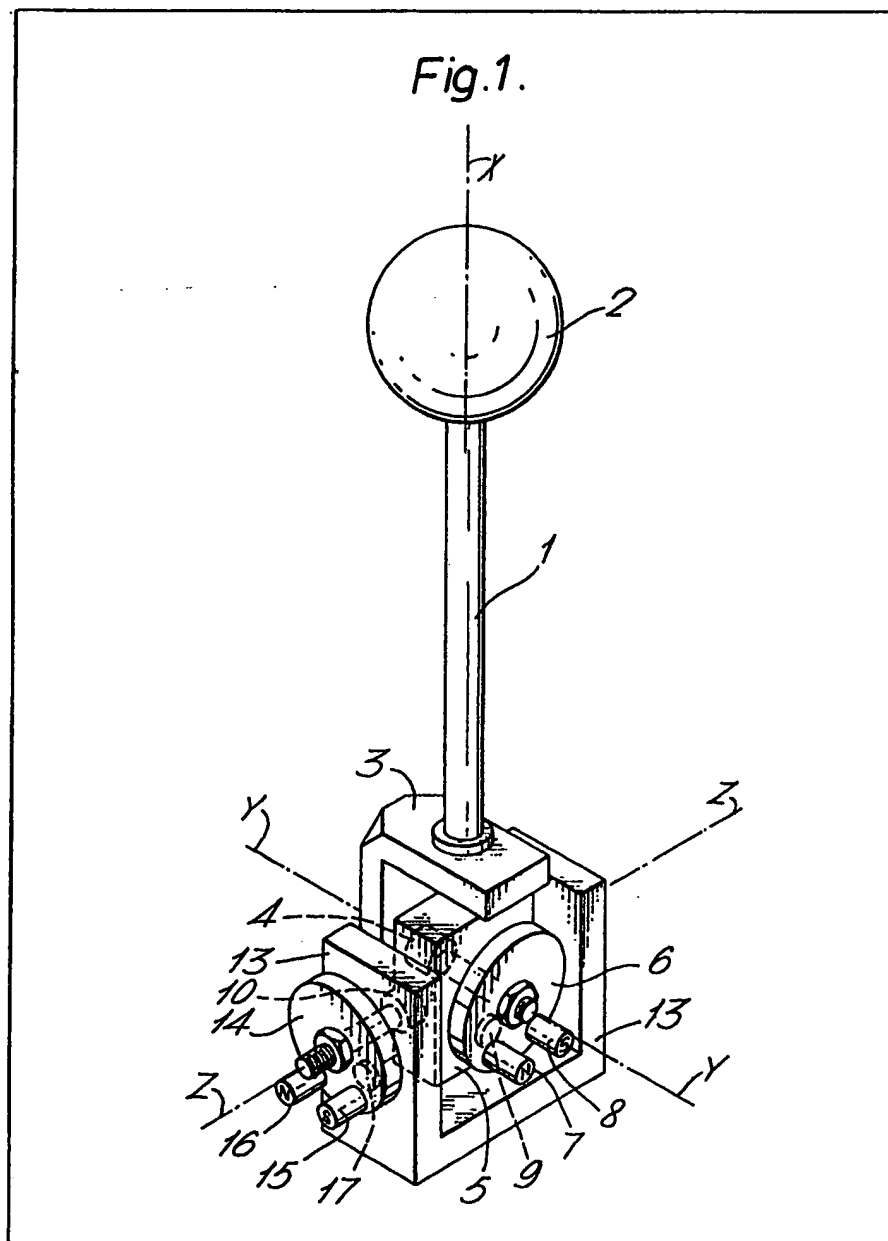
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(54) Control lever

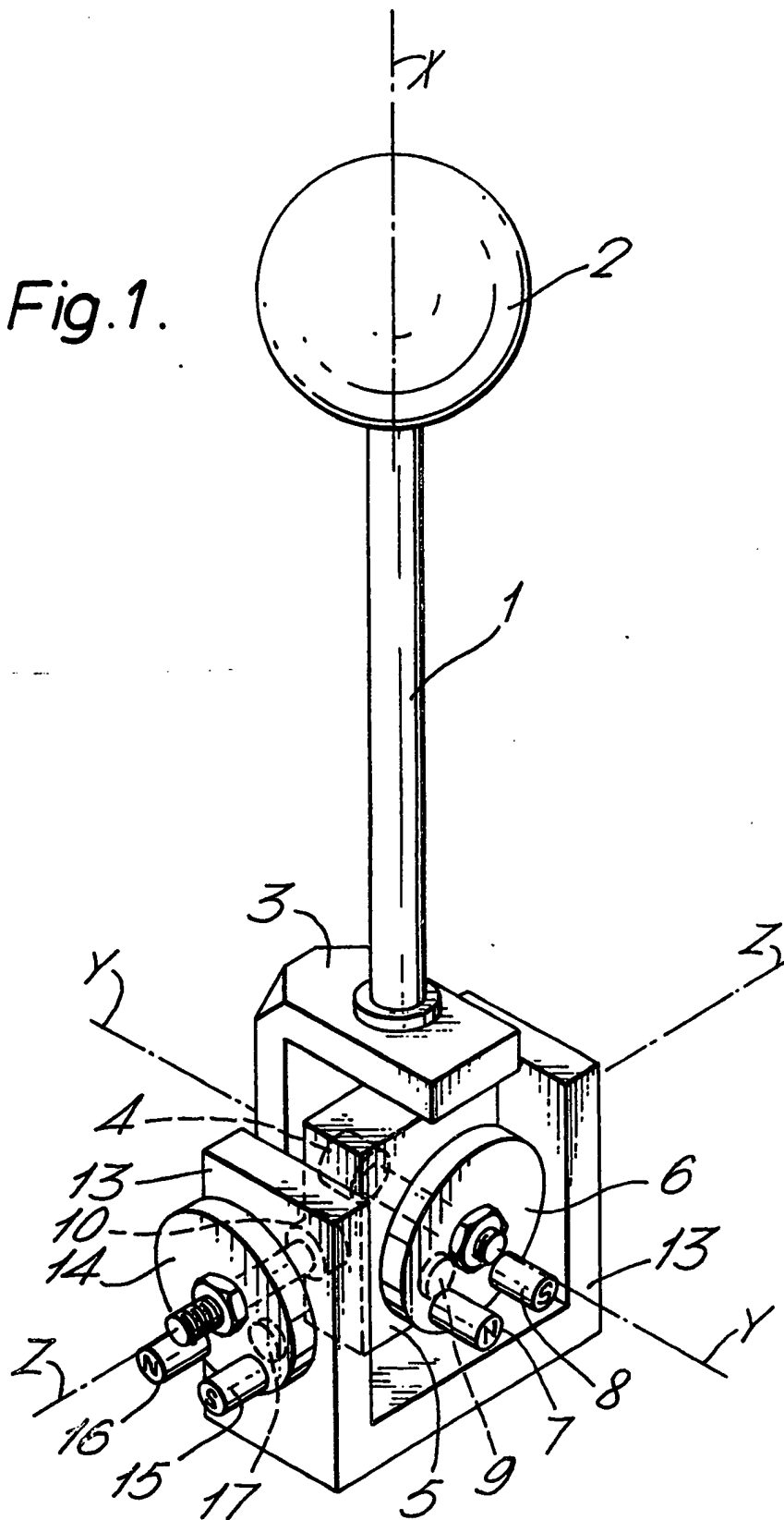
(57) A transducer device for producing electrical signals responsive to angular movement of a joystick control lever 1 includes two mutually perpendicular shafts 4, 10 which rotate in proportion to angular displacements of the control lever 1. The shafts 4, 10 carry respective discs 6, 14 on which pairs of permanent magnets 7, 8 and 15, 16 are carried, each pair of magnets being arranged so as to present opposite poles to respective Hall effect sensors 9, 17 so that the electrical outputs from the two sensors are proportional to the relative angular displacement of their associated magnets and, therefore, the angular displacements of the associated shafts 4, 10.



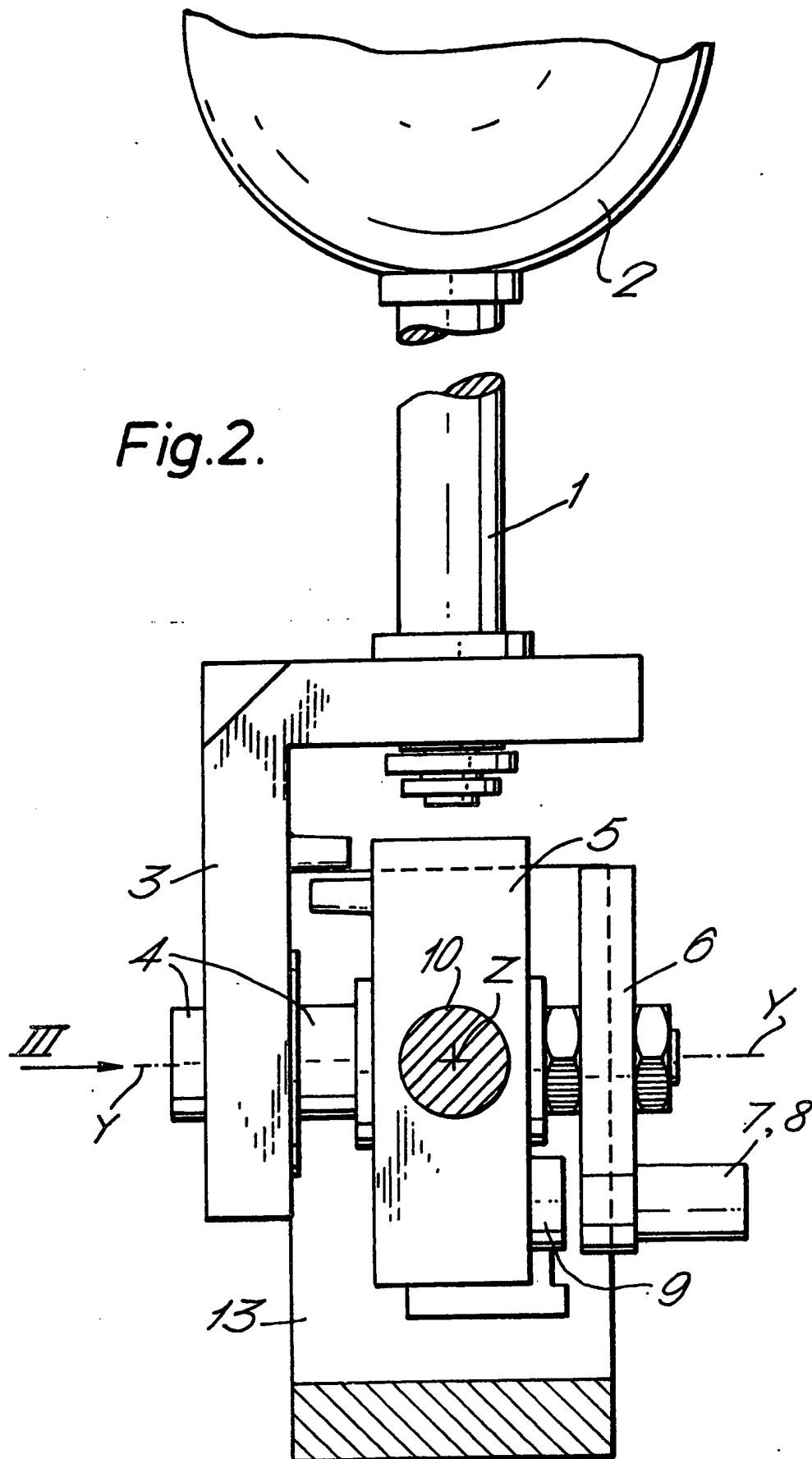
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Fig. 1.

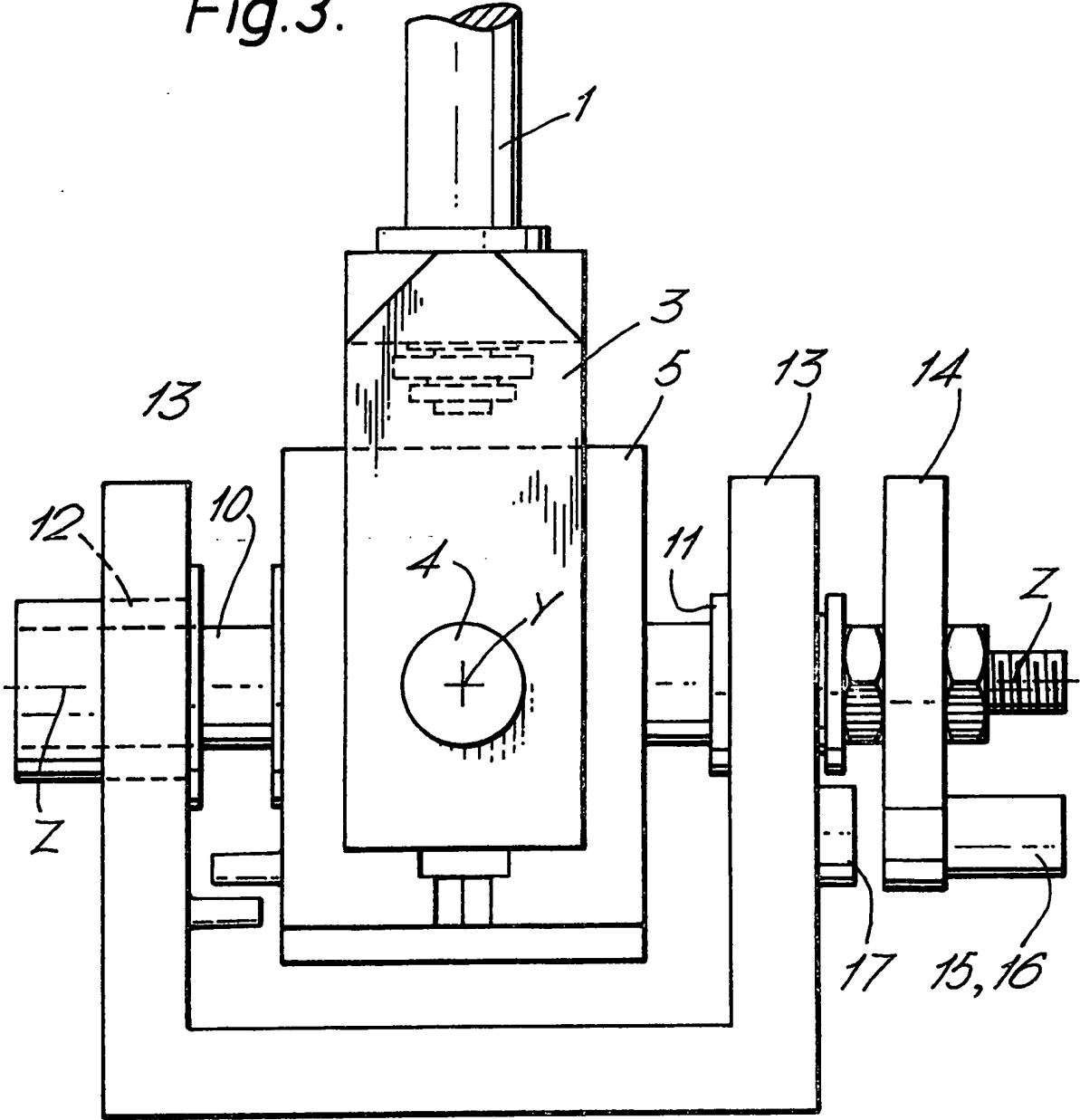


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Fig.3.



## SPECIFICATION

## Angular displacement transducer device

This invention relates to an angular displacement transducer device of the type in which angular movements of a manual control level or "joystick" produce electrical output signals corresponding to the angular movements. Such transducer devices have practical application in the servo-control of power operated vehicles such as wheel-chairs on invalid carriages or of remotely controlled handling devices.

A known type of device for providing electrical output signals representative of angular displacements of a "joystick" level employs potentiometric elements coupled to an angularly displaceable control lever so that angular displacement of the lever in a given plane causes rotation of a shaft of a potentiometer. In a universal "joystick" control the control lever is mounted so that its angular displacements have components in two mutually perpendicular planes which causes proportional rotation of respective mutually perpendicular shafts of two potentiometers. In practice such control devices require precision mounting of the control lever and its associated potentiometers, and also suffer from the disadvantage that the electrical output signals can be erratic, particularly if the potentiometers become contaminated with dust or dirt. Furthermore, since potentiometers are essentially electromechanical devices they are prone to mechanical wear and tear in use.

An object of the present invention is to provide an angular displacement transducer device capable of providing electrical output signals representative of angular displacements of a control lever, without requiring the use of potentiometers or other moving parts subject to mechanical wear.

According to the invention there is provided an angular displacement transducer device comprising an angularly movable control member coupled to a magnetic member which moves relative to a Hall effect sensor in response to movement of the control member, the sensor providing an electrical output representative of the movement of the control member.

The Hall effect is a phenomenon exhibited by metals and semi-conductors whereby the application of a magnetic field to a block of material carrying a current perpendicular to the field results in an observable potential difference across the block perpendicular both to the current flow and the magnetic field. The magnitude of the observed Hall potential difference is proportional to the applied magnetic field. Hall effect cells, usually incorporated in solid state integrated circuits, are commonly employed for the detection and measurement of magnetic fields.

The present invention utilises a Hall effect sensor to respond to the changing magnetic field at the sensor resulting from relative movement of the magnetic member coupled to the angularly movable control member. As a result an output

can be obtained which is proportional to the movement of the control member. The device can be arranged to be responsive to angular movement of the control member about a single axis, utilising a single Hall effect sensor and associated magnetic member. In a preferred embodiment of the invention, however, the angularly movable member is angularly displaceable in two mutually perpendicular planes and is coupled to two magnetic members which move angularly about respective mutually perpendicular axes in response to movements of the control member, the magnetic members cooperating with respective Hall effect sensors arranged to provide respective electrical outputs indicative of the components of angular displacement of the control member in the said planes.

The or each magnetic member may comprise an angularly movable support carrying at least one permanent magnet movable in an arc relative to the associated Hall effect sensor upon angular movement of the control member.

According to the intended practical application of the device, the or each Hall effect sensor may be a linear Hall effect device, which provides an electrical output signal proportional to the movement of the associated magnetic member, or a Hall effect switch device, which effects a switching operation in response to a predetermined displacement of the associated magnetic member. A number of Hall effect switch devices may be arranged in the path of movement of the magnetic member to provide discrete output signals at different angular displacements of the control member.

The invention will be further described, by way of example, with reference to the accompanying drawings, in which:

Figure 1 is a schematic perspective view illustrating the principle of operation of an angular displacement transducer device according to one embodiment of the invention;

Figure 2 is a diagrammatic side elevational view of an angular displacement transducer device according to an embodiment of the invention, and

Figure 3 is a plan view in the direction of arrow III in Figure 2, with the knob of the control lever removed.

The illustrated angular displacement transducer device has a manual control lever 1 surmounted by a control knob 2. The lever 1 is attached to one flange of an L-shaped support plate 3. The lever 1 is rotatably mounted on the support plate 3 so that the lever 1 can be freely rotated about its axis X.

The support plate 3 is rotatable about an axis Y perpendicular to the axis X of the control lever 1. Thus the plate 3 is supported upon a shaft 4 which is rotatable about the axis Y in a bearing block 5. On the opposite side of the bearing block 5 from the support plate 3 the shaft 4 carries a disc 6 which carries two peripherally mounted permanent magnets 7, 8 arranged with their magnetic axes generally parallel to the axis Y

spaced from the axis Y by equal radially distances, the magnetic flux directions of the two magnets 7 and 8 being opposite, as indicated diagrammatically in Figure 1. The disc 6 constitutes an angularly movable support for the two permanent magnets 7, 8, which, upon angular movement of the disc 6 in response to angular displacement of the control lever 1 about the axis Y, move in a circular path about the axis Y.

A Hall effect sensor 9 cooperates with the two permanent magnets 7, 8 and is located on the bearing block 4 at a position spaced from the axis Y by the same distance as the magnets 7, 8, the sensor 9 being equidistantly spaced from the two magnets 7, 8 in the normal or rest position of the device, as illustrated in Figure 1.

The bearing block 4 is itself rotatable about an axis Z perpendicular to the axes X, Y, defined by a shaft 10 which is supported on either side of the bearing block 4 by bearings 11, 12 carried by a fixed support yoke 13 (Figure 3). The shaft 10 carries at one end a disc 14 on which two further permanent magnets 15, 16 are located peripherally, in a similar manner to the location of the magnets 7, 8 on the disc 6, the axes of the two magnets 15, 16 being parallel and equidistant from the axis Z, and the flux directions of the magnets being opposite. A further Hall effect sensor 17 is carried by the fixed support yoke 13 and cooperates with the two magnets 15, 16. The Hall effect sensor 17 is located at a distance from the axis Z equal to the distance of the two magnets 15, 16 from the axis Z, and in the normal position of the control lever 1 the sensor 17 is equidistant from the two magnets 15, 16, as shown in Figure 1.

Respective biasing springs (not shown) of any convenient type are associated with the two shafts 5, 10 so as to bias the device into its normal rest position, in which the movable control lever 1 is centrally located, that is, vertical in the mounting position shown in Figure 1. Angular displacement of the control lever 1 about the axis Y will cause the magnets 7, 8 to move relative to the Hall effect sensor 9 so that the magnetic field in the direction of the axis Y passing through the sensor 9 will increase, the direction of this magnetic field being determined by the direction of the angular displacement of the lever 1 about the axis Y. Similarly, angular displacement of the control lever 1 about the axis Z will cause a corresponding displacement of the magnets 15, 16 relative to the Hall effect sensor 17.

The electrical outputs of the two Hall effect sensors will be representative of the components of the angular displacement of the lever 1 about the axes Y and Z respectively, the magnitude and sense of the electrical signals being representative of the magnitude and direction of these respective displacement components.

Where electrical outputs proportional to the angular displacement of the control lever are required each Hall effect sensor 9, 17 would comprise a linear output sensor, preferably of the type incorporating in an integrated circuit a

monolithic Hall cell, a linear amplifier, an emitter follower output stage and a voltage regulator. One example of such an integrated circuit is the type UGN-3501T manufactured by Sprague Electric Company, Semiconductor Division.

In an alternative embodiment of the invention one or more Hall effect switch devices may replace each Hall effect sensor, in order to provide digital outputs representative of the components of angular displacement of the control lever 1. Examples of integrated circuits incorporating such Hall effect digital switches are types ULN-3020T and ULS-3020T manufactured by the semiconductor Division of the Sprague Electric Company.

The permanent magnets 7, 8 and 15, 16 employed in the device are preferably samarium-cobalt sintered magnets. In place of the pairs of magnets 7, 8 and 15, 16, respective U-shaped permanent magnets may be employed, with opposite poles facing towards the associated Hall effect sensors 9, 17.

The entire device is enclosed in a box-like metal housing (not shown) with a suitably apertured plate through which the control lever 1 projects. The apertured plate may incorporate stop surfaces which predetermine the maximum angular displacements of the control lever 1 in any direction. A rubber or plastics boot or gaiter or synthetic rubber or moulded plastics (not shown) is located in the aperture in the housing and fitted around the projecting part of the control lever 1 to seal the housing against the ingress of dirt.

By arranging that the control lever 1 is freely rotatable in its supporting plate the device is rendered effectively tamper-proof, since such rotation has no effect on the integrity of operation of the device.

#### CLAIMS

1. An angular displacement transducer device comprising an angularly movable control member coupled to a magnetic member which moves relative to a Hall effect sensor in response to movement of the control member, the sensor providing an electrical output representative of the movement of the control member.

2. A device according to Claim 1, in which the angularly movable member is angularly displaceable in two mutually perpendicular planes and is coupled to two magnetic members which move angularly about respective mutually perpendicular axes in response to movements of the control member, the magnetic members cooperating with respective Hall effect sensors arranged to provide respective electrical outputs indicative of the components of angular displacement of the control member in the said planes.

3. A device according to Claim 1 or Claim 2, in which the or each magnetic member comprises an angularly movable support carries a pair of permanent magnet movable in an arc relative to the associated Hall effect sensor upon angular movement of the control member.

4. A device according to Claim 3, in which each angularly movable support carries a pair of permanent magnets, or a single permanent magnet, arranged with opposite poles facing
- 5 towards the associated Hall effect sensor, the latter being disposed symmetrically between said poles in a normal or rest position of the control member.
- 10 5. A device according to any one of the preceding claims, in which the or each Hall effect sensor is a linear Hall effect device providing an electrical output signal proportional to the movement of the associated magnetic member.
- 15 6. A device according to any of Claims 1 to 4, in which the or each Hall effect sensor is a Hall effect switch device.
7. An angular displacement transducer device substantially as herein described with reference to and as shown in the accompanying drawings.
- 20 New claims filed on 30 June 1981  
Superseded claims 1 to 7  
New claims:
1. An angular displacement transducer device comprising a control member angularly
- 25 displaceable in two mutually perpendicular planes, two magnetic members each of which is arranged to move angularly about a respective axis in response to movement of the control member in a respective one of said planes and independently of
- 30 movement of the control member in the other one of the planes, and respective Hall effect sensors associated with said magnetic members such as to provide respective electrical outputs indicative of the components of angular displacement of the
- 35 control member in the said planes.
2. A device according to Claim 1, in which each magnetic member comprises an angularly movable support carrying at least one permanent magnet movable in an arc relative to the
- 40 associated said Hall effect sensor upon angular movement of the control member in the appropriate one of said planes.
3. A device according to Claim 2, in which each angularly movable support carries a pair of permanent magnets, or a single permanent magnet, arranged with opposite poles facing
- 45 towards the associated Hall effect sensor, the latter being disposed symmetrically between said poles in a normal or rest position of the control member.
- 50 4. A device according to any one of the preceding claims, in which the or each Hall effect sensor is a linear Hall effect device providing an electrical output signal proportional to the movement of the associated magnetic member.
- 55 5. A device according to any of Claim 1 to 3, in which the or each Hall effect sensor is a Hall effect switch device.
6. A transducer arrangement comprising a control member angularly displaceable in two mutually perpendicular planes, two magnetic members each of which is arranged to move angularly about a respective one of two mutually perpendicular axes in response to movement of
- 60 the control member in a respective one of said planes and independently of movement of the control member in the other one of the planes, a respective single Hall effect sensor associated with each said magnetic member for providing an electrical output indicative of the angular
- 70 movement of the associated magnetic member, and d.c. supply means for said Hall effect sensors, each said magnetic member comprising permanent magnet means so arranged as to set up through the corresponding sensor a magnetic field the operative component of which, with regard to operation of the sensor, reverses in direction upon movement of the magnetic member through a reference position thereof.
- 75 7. An angular transducer device substantially as hereinbefore described with reference to the accompanying drawings.
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